ELECTRICAL FIRES

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FM Global

1.0 SCOPE

This data sheet provides general loss prevention information and recommendations to prevent fires initiated by electrical ignition. All electrically initiated fires are caused by arcing, conductor overheating or component failure. Presently the data sheet only includes information on High Intensity Discharge (HID) lighting. The operating standard will be expanded to include other electrical ignition sources.

1.1 Changes

This is the first publication of this document.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 High Intensity Discharge Lighting

2.1.1 Introduction

Apply these recommendations to any wattage High Intensity Discharge (HID) lamps over combustible occupancies or in combustible buildings. High Intensity Discharge electric lighting includes mercury vapor, metal halide and high pressure sodium lamps. In lieu of the following recommendations, replace all HID lighting with non-HID.

2.1.2 Ignition Source Control

2.1.2.1 Install fixtures and lamps that should meet UL 1572, *High Intensity Discharge Lighting Fixtures* or IEC equivalent. Provide fixtures with a lamp containment barrier for use with the HID lamps. The lamp containment barrier will prevent fragments of hot glass or quartz from falling and igniting combustibles under them. Follow the lamp manufacturer's instructions for installation of the lamp to ensure proper application of the lamp, fixture and associated auxiliary devices.

2.1.2.2 Provide enclosed fixtures (External shielding) for all new installations of High Intensity Discharge lamps. Use external shields made of borosilicate glass that do not leave any gaps between the glass and the fixture. Do not use acrylic or polycarbonate plastic type external shields, as thermal aging may cause the shield to lose its ability to contain the hot glass fragments if a nonpassive failure of the arc tube occurs.

Note: Retrofit external shielding to existing fixtures in accordance with UL 1572 or IEC equivalent. Do not leave any gaps between the glass and the fixture. Contact the manufacturer of the fixture to ensure safety.

Note: Retrofitting shielding may not be practical due to costs, or it may increase the hazard due to overheating. HID lamps can generate substantial heat. The equipment design should consider the need to dissipate excessive heat. Some lamps may require additional ventilation to ensure proper operation and prevent damage to the fixture. Carefully select materials used for the lamp holder, reflectors, shields and lamp housing, since the lamp surface temperature may reach 1230°F (700°C). Lamp base temperatures should be limited to less than 662°F (350°C)to prevent wire and base cement deterioration.

2.1.3 Operation and Maintenance

2.1.3.1 Turn off HID lamps that do not have borosilicate glass external shields for at least 15 minutes each week.

2.1.3.2 Perform the following operation and maintenance on all HID lamps:

1. Replace the lamp at or before the end of its rated life, preferably by group relamping.
2. Replace the lamp if the outer glass has been scratched, cracked or damaged in any way.
3. Protect the lamp from contact with liquid, moisture, dust, dirt, oils, etc.
4. Never touch the lamp with bare hands.

2.1.3.3 Always follow the requirements shown on manufacturers' bulletins.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 Loss History

Loss history has identified that metal halide lamps and other HID lamps as potential ignition sources. Factory Mutual Research loss data has revealed that the frequency of failure is approximately three losses per year. There have been 29 failures reported in the past 10 years. Of the 29 losses, 14 had metal halide lamps, 12 had mercury vapor lamps and three had sodium vapor lamps.

Many, but not all, of the bulb manufacturers have stated that the HID bulbs can fail violently. FM Global feels that the possibility of violent failure of this type of bulb extends to all manufacturers.

3.1.1 High Intensity Discharge Lighting

3.1.1.1 Introduction

High intensity discharge (HID) electric lighting includes mercury vapor, metal halide, and high pressure sodium lamps.

This type of lamp, (Fig. 1) produces light by electrically exciting a mixture of metallic vapor and halides. The lamp consists of a fused silica/quartz arc tube that confines the electric discharge and the associated gases. The arc tube is dosed with mercury, metal halide salts and filled with the inert gas, argon. The arc tube is under a vacuum, 0.39atm./0.5psi when the lamp is at ambient temperature and de-energized. The arc tube is enclosed in a glass bulb or outer jacket to exclude air. The bulb is filled with nitrogen which prevents oxidation of metal parts, stabilizes the operating temperature and reduces UV radiation. High Intensity Discharge lighting operates at very high temperatures and pressures [(up to 2000°F (1100°C) and 50 psi (350 kPa)]. Because it is a discharge lamp, it does not instantly re-light and will take some time (two or more minutes) to reach full brightness after a power loss.

3.1.1.2 Available Capacity (Wattage) of Bulbs

Generally, the following wattage bulbs are available: 75, 100, 150, 175, 250, 400, 1000, and 1500 W. The capacity of the lamp can be read off the markings on a spare bulb; purchase orders may also confirm the bulb type in use. ANSI markings (used by all American and some European and Japanese manufacturers) consist of five letters or numbers; the first letter denotes the type of lamp (H for mercury, M for metal halide, S or high pressure sodium). The lamp capacity is listed after the five letters or numbers. For example, M95PK-400/BVU stands for a metal halide lamp with a nominal wattage of 400 W.

3.1.1.3 Compatibility of Fixtures (Fittings)

The fixtures (fittings) and ballast used with the lamp must be appropriate for the bulb's wattage and socket type. The bulb manufacturer specifies what type of fixture should be used. Install the HID lamp in accordance with the manufacturer's HID fixture requirements. Installation instructions can usually be found with the spare lamp carton or is written on the side of the ballast/fittings. The rating of the fixture should match the rating of the lamp, and the socket types should match. Lamp manufacturers have three basic "codes" to identify appropriate fixture for a particular lamp as follows:

E — Enclosed fixture required.

S — Open fixture restricted burning position (normally ±15°) otherwise an enclosed fixture is required.

O — Open fixture permissible.

Fixture manufacturers are required to use UL (IEC) listed materials that not only contain the hot quartz from the ruptured arc tube but will prevent ignition. The UL 1572 or IEC equivalent standard allows three methodologies for arc tube containment: 1) Enclosed fixture, 2) Quartz shroud around the arc tube in an open fixture (Fig. 3), 3) Permits lamp manufacturers to specify specific lamps, usually 400 and 1000 watt, for open fixture operation based on failure rate, rather than design.

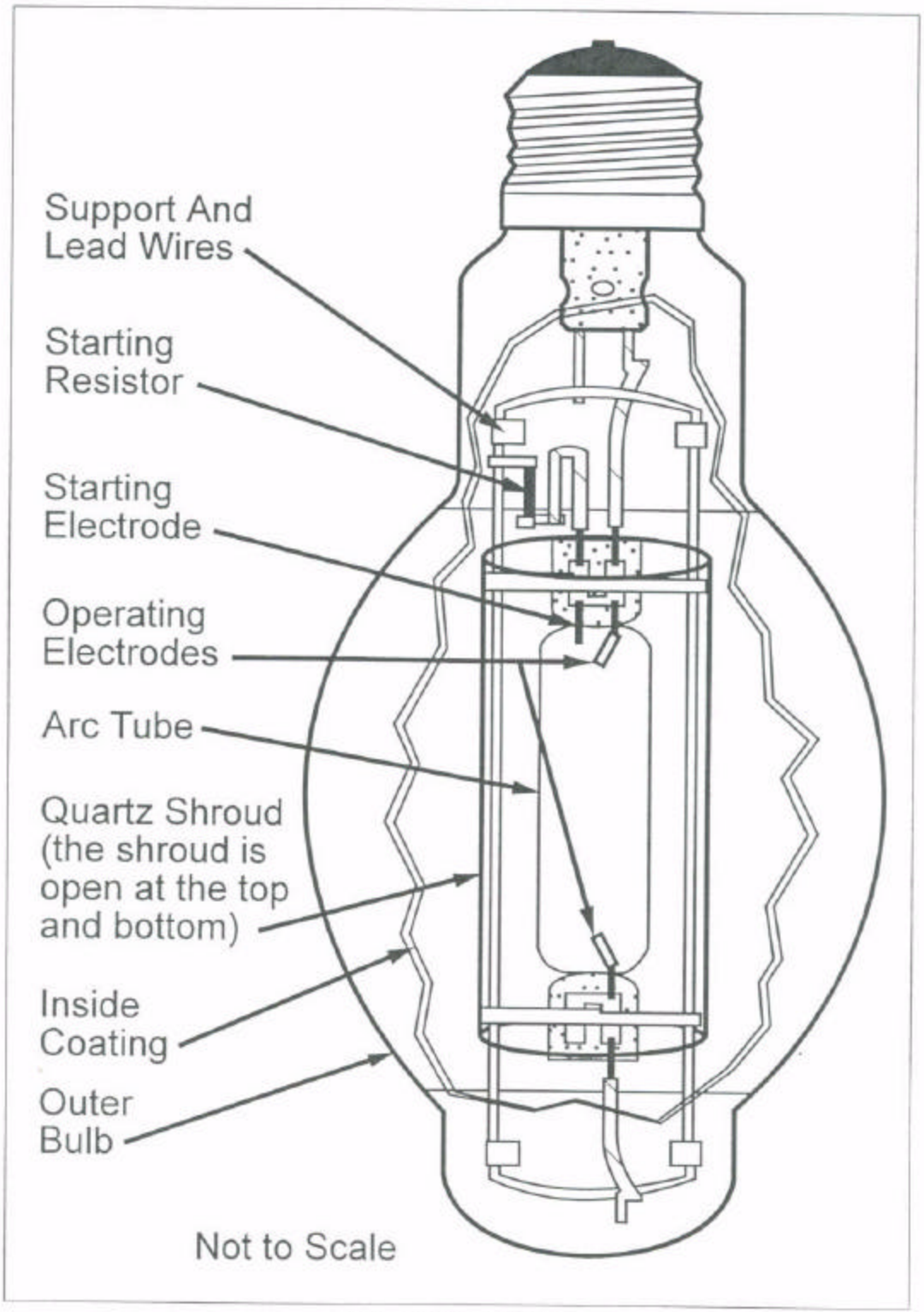

Fig. 1. Schematic of HID lamp.

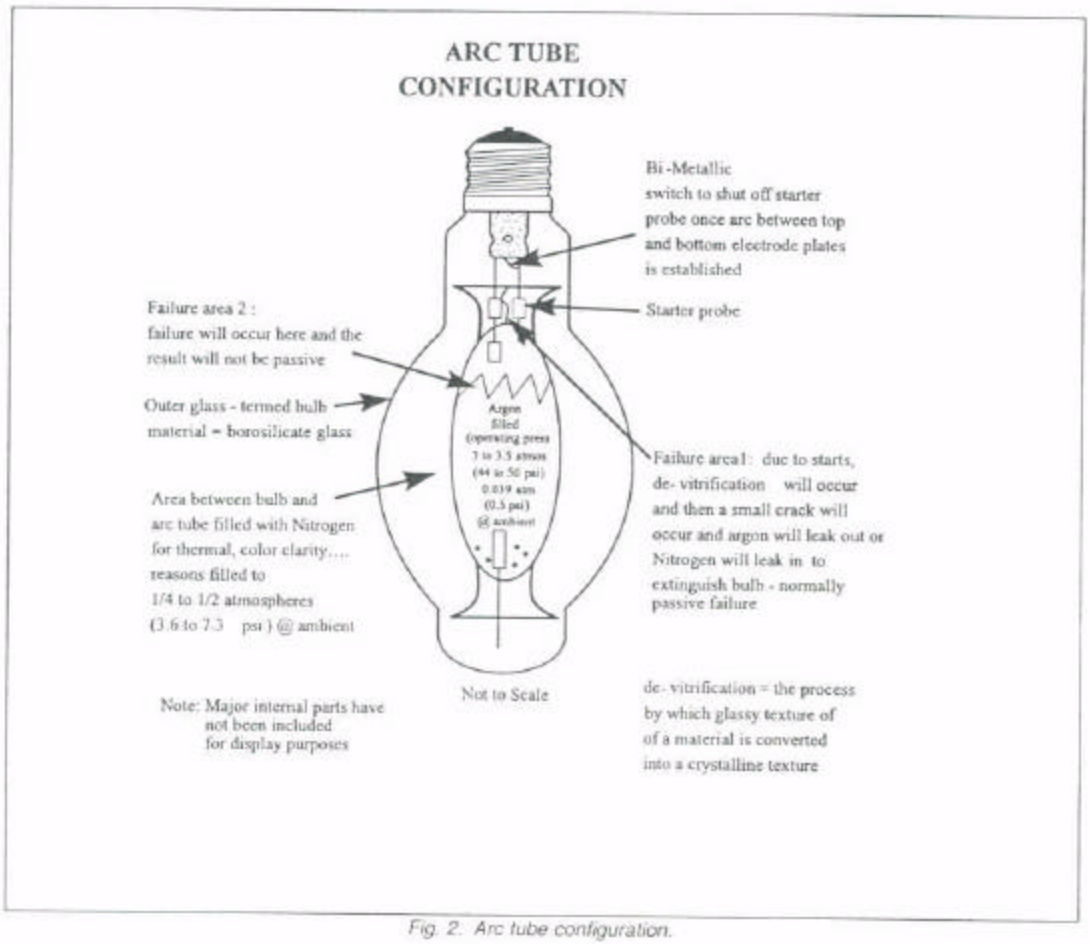

Fig. 2. Arc tube configuration.

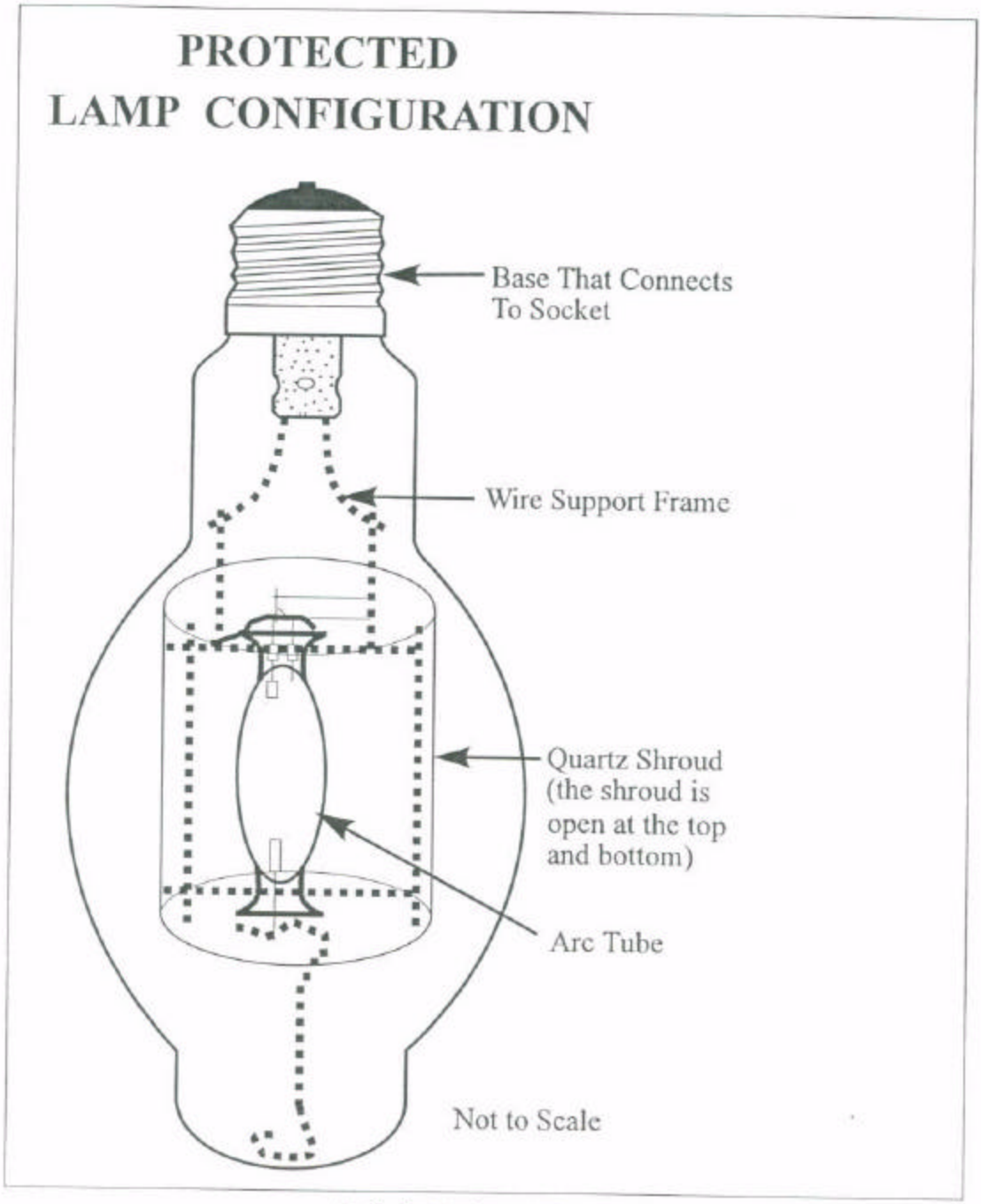

Fig. 3. Protected lamp configuration.

3.1.1.4 Burning Position

The lamp is designed to operate in a specific orientation in respect to the base. Typical positions are horizontal, vertical base up or vertical base down. Again, the bulb manufacturer will specify the burning position. The wrong burning position will increase the likelihood of a violent failure.

3.1.1.5 Lamp Cycling

Many manufacturers recommend that the unshielded HID bulbs be turned off for a continuous 15-minute period every week. HID lamps that continuously operate are not stressed in the same manner as lamps that are periodically turned off. Cycling the bulbs allows for the bulb to cool and frequently will permit malfunctions to occur in a less harmful manner. If there are imperfections in the lamp, it may then fail in a passive manner and will not ignite upon re-energizing. While cycling is not a guarantee that the bulb will not fail during operation, it can reduce the potential. (There have been losses in the FM Global system, when cycling was practiced before the loss.

3.1.1.6 Externally Shielded vs. Shrouded (Integral Shielding)

Currently there is no supporting data that shrouded (integral shielded) lamps will reduce the risk of ignition sources to an acceptable level. One manufacturer of an integral shielded bulb states: " This new lamp type is specifically designed for vertical operation in open fixtures ... which reduces the risk of lamp shattering." Note that the statement says "**reduces the risk**" and not "eliminates the risk".

3.1.1.7 Service Life of Bulbs

The specifications of various bulb manufacturers indicate that the life expectancy of bulbs can range from approximately 3000 hr. (approximately 4 months) to 20,000 hr. (approximately 2 ¼ years).

The following table presents a range of operating service hours as found in product literature from various manufacturers.

Bulb Wattage, w	*Service Life, hr*
100	6,000 to 10,000
150	10,000
175	6,000 to 7,500
250	10,000
400	15,000 to 20,000
1000	9,000 to 12,000
1500	3,000 to 12,000

Factors that affect lamp life include high and low operating voltages, extremely high operating temperature, and marginally operating auxiliary equipment (ballasts, capacitors, ignitor, and/or power supplies. Most lamps fail to reignite at end of life. This is due to either the argon leaking out of arc tube or nitrogen (ion inhibiter) leaking into the arc tube. Most manufacturers recommend group relamping after approximately 60-75% of rated life. Light output and color shift occur over the life of the lamp. This is the result of the loss of light producing chemicals within the arc tube and the darkening of the inner walls of the arc tube. The light output of HID lamps decreases to approximately 60% of initial rated light output at about half of its rated life.

3.1.1.8 Failure Mode

Failure of a HID lamp can occur in several ways (Fig. 2). Scratches on the outer envelope, direct contact with water, or excessive pressure can cause these lamps to break. HID lamps and their arc tubes operate at extremely high temperatures and may shatter as a result of miss application, incorrect burning position, system failure or other factors. De-vitrification of the arc tube glass occurs when the quartz reacts with the halogen gas. A small crack will occur normally in the vicinity of the electrode, and either the argon will leak out of the arc tube or the nitrogen gas will leak into the arc tube. Normally the lamp will fail to reignite. The probability that the arc tube will implode towards end of life increases significantly. If the lamps are cycled on and off periodically, it is much more likely to fail to restart rather than fail violently at end of life.

If the arc tube ruptures under normal operating conditions, the arc tube fragments can penetrate the outer bulb if a shroud is not effective or present. Extremely hot glass and lamp parts can be released into the surroundings if fragments are not contained by the shroud or an external shield, causing a risk of fire if combustible materials are present.

3.2 Illustrative Losses

3.2.1 Retail Store

Two sprinklers promptly controlled a fire started by a High Intensity Discharge (HID) lamp. The bulb jacket parted and spewed hot quartz pieces onto a plastic light diffuser beneath and the occupancy below, during an unattended period at this retail store. Sprinklers controlled the fire and limited damage.

The arc tube of the High Intensity Discharge lamp ruptured and discharged hot [estimated 2000°F (1100°C)] quartz onto the plastic light diffuser beneath, which in turn dropped hot or flaming matter on the occupancy beneath.

The manufacturer had apparently advised purchasers of these High Intensity Discharge lamps of this potential failure mode. A program to replace the plastic light diffusers beneath the lamp was being investigated. The lamp may have gone beyond its 10,000-hr rated life. The life rating is not described on the package in which the replacement bulbs are received. The preventive maintenance advice from the manufacturer (to turn the lamps off at least 15 minutes a week) was apparently being followed at this store. Energy conservation was also a factor in the lighting on and off cycle.

3.2.2 Storage of Granular Plastic Pellets

A fire started in double-row rack storage of bags containing granular plastic. It was probably caused by a defective electrical component associated with the lamps. The fire was promptly extinguished by the ceiling sprinkler system. Damage was limited to two burnt pallet loads of stock and wetted adjacent storage.

Suspected cause of the fire is an arc on the mercury vapor lamp ignition condensor, resulting in hot particles falling on and igniting the storage in the rack. This warehouse is provided with mercury vapor lamps (125 to 250 W, 220 V) at the ceiling level. It could not be ascertained when these lamps were installed, but it was reported that this lighting system is approximately twenty years old. An ignition condensor of a mercury vapor lamp had been damaged in normal operation. This electrical component was not fully enclosed, thus allowing molten metal to escape.

3.2.3 Multi-tenanted Warehouse

Hot fragments released from a ruptured metal halide light bulb or fixture are the probable cause of a fire which resulted in damage to insured storage at this leased warehouse.

The storage involved in the fire was reported to be 6 to 8 ft (1.8-2.4 m) high and consisted mostly of plastic wrapped and cartoned nylon "gear bags" and some corrugated carton flats. Higher storage ranging from 8 to 12 ft (2.4-3.7 m) high surrounded the storage area across the narrow access aisles from the area of origin. This storage included mostly vinyl inflatable rafts. The light fixtures were at least 10 ft (3.0 m) above the highest storage in the building, and about 18 to 20 ft (5.5-6.1 m) above the storage involved in the fire.

The building lights are turned off each night. The original lights in the warehouse, and those located over this fire incident and over the office, were reported to be Sylvania 1,000-W metal halide lamps. The lamps currently being used to replace burned out lamps are GE 1,000-W multi-vapor lamps. None of the fixtures have shields fitted.

This is a no smoking facility, except for the office and breakroom. Indications are that this policy was strictly observed. No hot work had been conducted on site for months.

3.2.4 Storage of Mercury Vapor Lamp Fabric

Sparks from a ruptured overhead mercury vapor lamp ignited rolls of synthetic fabric stored in multiple-row racks to 16 ft (4.9 m) high at a cloth finishing plant. Ninety-six ceiling sprinklers operated. In-rack sprinklers were not provided. Ceiling sprinklers, strong water supplies, and prompt fire department response limited fire damage. Smoke and water damage were extensive.

The mercury vapor lamps did not have an enclosure to keep sparks from spreading to storage. Lack of a wall between the warehouse and a manufacturing building allowed smoke to damage production machines. Lack of in-rack sprinklers allowed the fire to operate an excessive number of ceiling sprinklers.

3.2.5 Roll Paper Storage

The bursting of a mercury vapor lamp is the probable cause of a fire occurring in a roll paper storage area at a tissue products manufacturing plant. The water density available from the hydraulically designed sprinkler system was inadequate for the occupancy because the system was designed to protect paper converting lines. Paper rolls were stored on end, two high, to a height of 17 ft (5.2 m). The lamp that probably started the fire was the only one in the area not provided with a safety cover.

Damage was limited by a strong water supply and an effective emergency organization.

A total of about 2,000 tons (1,800 metric tons) of roll paper were burned, charred or wet. Also damaged were aluminum roof panels, plastic skylights and electric lights and wiring. Although paper converting machines were not damaged, production was interrupted for two days for clean-up.

3.2.6 Plastic and Paper Storage Warehouse

A hot fragment from a ruptured metal halide light bulb or fixture is the probable cause of a fire in a 200,000-ft^2 (19,000 m^2) warehouse with two tenants. The sprinklered building has precast concrete walls and a Class II insulated steel deck roof. The tenants stored promotional merchandise and paper business records.

The operation of five sprinklers confined the fire to a 500-ft^2 (46 m^2) area utilized for the storage of plastic and paper promotional items stored on pallets to a height of 8 ft (2.4 m). Water damage occurred over an area of 10,000 ft^2 (930 m^2). Smoke damage was observed throughout the building. No structural damage was reported.

3.2.7 Computer Equipment Assembly Plant Storage

An unshielded, 400-Watt metal halide light over rack storage "popped", igniting rack storage of plastics at a computer equipment assembly plant. Sprinklers operated and controlled the fire. Nonthermal damage accounted for most of the loss.

About three years before the fire, FM Global had determined that the rack storage was inadequately protected and had recommended an upgrade. About two years later, the sprinkler system was reinforced in accordance with accepted plans.

About two years before the fire, FM Global had also recommended the metal halide lights be cycled weekly. The insured established a weekly cycling program, so the recommendation was reported as completed some four months before the fire. Unfortunately, in those four months, key personnel changes occurred and the cycling program was not being followed.

This loss illustrates the danger metal halide lights present as an ignition source and the importance of having adequate sprinkler protection.

Metal halide lamps without shields in a warehouse for storage of combustibles is a dangerous situation. Recommendations to provide shields or to eliminate the exposure altogether should be made with a strong sense of urgency.

4.0 REFERENCES

UL 1572, *High Intensity Discharge Lightning Fixtures.*

APPENDIX A. GLOSSARY OF TERMS

Accessibility Barrier: a material provided to limit access to uninsulated live parts; and live parts insulated with materials not intended to be subject to user contact. All or part of the barrier may also serve as an enclosure as defined below.

Arc tube: a completely sealed quartz tube where the electrical discharge (arc) occurs.

Ballast: an auxiliary piece of equipment designed to start and properly control the flow of power to the gas discharge light source such as HID lamps.

Base: the end of the lamp that inserts into the lamp socket.

Bulb: the other jacket or envelope of a lamp, is the glass enclosure that covers the frame and arc tube assembly.

Enclosure: a material provided to enclose electrical parts and components that may be considered to involve a risk of fire. All or part of the enclosure may also serve as an accessibility barrier as defined above or as a recessed housing as defined below.

Field-Connected Ballast: a ballast that may or may not be provided with the fixture and that is intended to be electrically connected to the fixture during installation. The ballast may be mounted on the fixture or mounted remotely.

High Intensity Discharge (HID) Lamp: a general term for mercury, metal halide and high pressure sodium lamps. HID lamps contain compact arc tubes which enclose various gases and metal salts operating at high pressures and temperatures.

High Pressure Sodium Lamp: an HID lamp which produce light by an electrical discharge through sodium vapor operating at high pressure and temperature.

Luminaire: a complete lighting unit consisting of a lamp, ballast, as required together with the parts designed to distribute the light, position and protect the lamps and connect them to the power supply (fixture).

Mercury Lamp: an HID lamp in which most of the light is produced by radiation from excited mercury vapor operating at high pressure and temperature. Phosphor coatings on some lamp types add additional light and improve color rendering.

Metal Halide Lamp: an HID light source in which the light is produced by the radiation from mercury, plus halides of metals such as sodium, scandium and indium. Some lamps may also use phosphor coatings.

Lamp: the device, commonly called a light bulb or bulb, intended to be inserted into a lampholder (socket) to produce light.

Lamp Containment Barrier: a barrier that consists of the top, sides, and bottom that enclose the lamp compartment. The barrier may consist of a metal housing (recessed or otherwise), a polymeric enclosure, a glass diffuser or lens, a metal canopy, a metal screen, or the like.

Pendant Fixture: a fixture that is supported by and suspended from an outlet box by a chain, cord, stem, or cable.

Recessed Fixture: a fixture intended to be installed in a hole in a wall, ceiling, or in-ground surface such that all or part of the fixture is behind the mounting surface.

Recessed Housing: the metal of a recessed fixture that serves to close off the hole provided in a ceiling or wall surface to mount the fixture. It does not necessarily enclose wires or the like.

Remote Ballast: a ballast that is not mounted on a fixture or one that is mounted on the fixture 18 in. (457 mm) or more from the recessed housing as measured from the nearest point on the ballast to the nearest point (other than an incidental projection) on the recessed housing. The ballast may or may not be provided with the fixture.

Shroud: a quartz tube around the arc tube.